THE INCIDENCE OF SCLERODERRIS PINE CANKER ON NATIONAL FOREST LANDS IN THE LAKE STATES

by Charles E. Cordell and Darroll D. Skilling

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Forest Service · U. S. Department of Agriculture

COVER

THE YELLOW-GREEN DISCOLORATION SYMPTOM OF SCLERODERRIS CANKER ON RED PINE. THE BARK WAS REMOVED FROM THE STEM TO SHOW THE DISCOLORATION IN AREAS WHERE S. LAGERBERGII WAS ACTIVE.

F O R E W O R D

This survey was a cooperative project between the Forest Insect and Disease Control Branch, Division of State and Private Forestry, Eastern Region, Forest Service, U. S. Department of Agriculture, and the Division of Watershed Management and Forest Protection Research, North Central Forest Experiment Station.

This material will be condensed and published in a Station paper by the North Central Forest Experiment Station. However, the present report lists the survey results in more detail and provides specific recommendations to aid in making reforestation decisions.

Acknowledgment of assistance in making the field survey is due the following National Forest personnel:

Ottawa N. F.	-	W. L. Kickbusch and W. E. Morden
Hiawatha N. F.	-	G. N. Semmens, R. F. Fowler, and S. M. Sager
Nicolet N. F.	-	R. K. Train, S. O. Ryan, and H. H. LaBumbard
Chequamegon N. F.	-	J. R. Hornick and J. R. Law

The assistance provided by Ranger District personnel on the four Forests surveyed is also greatly appreciated.

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THE INCIDENCE OF SCLERODERRIS PINE CANKER ON FOUR NATIONAL FORESTS IN THE LAKE STATES

by

Charles E. Cordell and Darroll D. Skilling 1/

ABSTRACT

During the summer and fall of 1965, a survey was conducted in the Lake States to determine the distribution and intensity of **Scleroderris pine canker** on national forest land. **Scleroderris pine canker** , a disease caused by the fungus Scleroderris lagerbergii Gremmen, has a long history of injuries to young pine plantations and nurseries in Europe. Twenty ranger districts on four Lake States National Forests with two- to ten-year-old red and jack pine plantations were surveyed for the disease.

The survey results showed that **Scleroderris pine canker** was widespread over the Ottawa and Hiawatha National Forests in the Upper Peninsula of Michigan and the Nicolet and Chequamegon National Forests in northern Wisconsin. The disease is present and causing mortality on all 20 ranger districts where red or jack pine has been planted since 1955. Sixty-seven percent of the 176 red pine plantations, and 86 percent of the 14 jack pine plantations sampled on the four forests, were infected. Mortality averaged 40 percent and 36 percent, respectively.

1/ Plant Pathologists, Division of State and Private Forestry, Eastern Region, Forest Service, U. S. Department of Agriculture, and Division of Watershed Management and Forest Protection Research, North Central Forest Experiment Station, respectively.

INTRODUCTION

During the past several years an increasing number of young red pine (Pinus resinosa Ait.) and jack pine (Pinus banksiana Lamb.) plantations in Upper Michigan and Wisconsin have suffered from poor growth and mortality. Damage was first noted in red pine plantations on the Kenton Ranger District, Ottawa National Forest, in the spring of 1951. Severe red pine plantation damage was also reported on the Forest's Ontonagon Ranger District, in 1956. Similar damage was noted in a fifteen-year-old red pine plantation, however, on the Dunbar Experimental Forest near Sault Ste. Marie, Michigan in 1942 (4).

In 1957, the North Central Forest Experiment Station established a study to identify the factors associated with failing red pine plantations on the Kenton Ranger District (1). The results of this survey showed the youngest age class sampled (5 to 9 years old) had only 13 percent survival. The other two age classes sampled, 10 to 14 and 15+ years old, had 38 percent and 40 percent survival, respectively. The survey indicated that mortality was severe in all three age classes sampled but was most severe in the youngest age class. This condition was also found on living trees in natural red pine stands.

A field study to determine plantation mortality rates on the Ontonagon Ranger District in 1958 showed 55 percent mortality over a 2-year period. By 1960, the Kenton Ranger District had approximately 1,200 acres of severely damaged red pine plantations.

Although the problem has existed on the Ottawa and Hiawatha National Forests for a number of years, the causal agent was not determined until 1964. John Ohman, Plant Pathologist, North Central Forest Experiment Station, isolated a fungus from both red and jack pine stem cankers which he identified as Scleroderris lagerbergii Gremmen. Jorgensen, at the University of Toronto, had previously isolated the same fungus from diseased red pine in Ontario, Canada, in 1962. These are the first confirmed reports of this fungus in North America.

Although previously unreported from North America, S. lagerbergii has a long history of pine plantation and nursery injury in Europe (2, 11, 12). The disease caused by this fungus, **Scleroderris pine canker** , was first described by Brunchorst in 1888 (3). Since this time, **Scleroderris pine canker** has periodically caused serious mortality of conifers in Europe. Approximately

75 million Scotch pine seedlings, along with extensive forest areas, were damaged in Sweden during the period 1950-1960 (7). Twenty million seedlings were lost in 1959 alone. The fungus is damaging, primarily to Corsican pine in Great Britain (9). Jorstad considered the disease responsible for the virtual disappearance of Austria pine from Scandinavia (6).

No economic evaluation has been made of this disease in North America. However, a Canadian survey of 50 red pine plantations in 1963 revealed that approximately two-thirds of them had 50 percent or more mortality (8). **Scleroderris pine canker** has been implicated in these plantations. In Upper Michigan, a 5-year-old red pine outplanting study on five different sites had 43 percent mortality due to **Scleroderris pine canker.**

On the basis of severe damage in Ontario and Michigan plantations and the history of this disease in other countries, it was imperative to determine its present and potential impact on the Forests of the Lake States Region.

During the summer and fall of 1965, a survey was conducted to determine the distribution and intensity of **Scleroderris pine canker** on four National Forests in the Lake States.

SURVEY METHODS AND PROCEDURES

The **Scleroderris pine canker** survey was conducted on the Ottawa and Hiawatha National Forests in Upper Michigan and the Nicolet and Chequamegon National Forests in northern Wisconsin. Twenty ranger districts on these four forests with two- to ten-year-old red and jack pine plantations were surveyed. Field observations had indicated that this age class was most susceptible to the disease. Host symptoms, resulting from **Scleroderris pine canker**, were also easier to detect in this age class.

The number of plantations sampled was determined by the plantation acreage in this species and age class on each district. The plantation acreage was compiled from available ranger district and Forest data. A minimum of five plantations were surveyed when possible, on each district. One additional plantation was sampled for each 500 acres of two- to ten-year-old red and jack pine plantations present on the District. The sample plantations were selected at random with the two species being sampled proportionately to the total plantation acreage they represented. The sample was modified; whenever possible, at least one plantation per township was sampled. This provided a broader and more representative distribution of the disease.

On each sample plantation, the first step was to determine whether or not **Scleroderris pine canker** was present. A minimum of 50 suspect trees was examined in each plantation. A suspect tree was any tree showing disease symptoms such as dead lateral branches and terminals (flagging) or stem cankers. Trees in depressions or "frost pockets" were examined first as the disease had been observed most frequently in these areas. The bark was removed from damaged portions of the symptomatic trees to determine the presence or absence of a yellow-green discoloration beneath the bark. This discoloration proved to be a very reliable diagnostic symptom of the disease. Over 90 percent of the samples taken from trees with the yellow-green discoloration were found positive by laboratory diagnoses.

Therefore, the plantation was considered uninfected if the discoloration was not found on any of the 50 symptomatic trees examined. If the discoloration was found on any one tree, however, the plantation was recorded as infected, but samples were taken from the trees showing the discoloration. Precautions were taken to keep the samples at temperatures below 60° F. until they reached the laboratory. The fungus was identified in the laboratory by either the characteristic asexual spore produced (pycnidia with four-celled, sickle-shaped conidia) or by cultural diagnosis, using a modified malt agar medium.

The next step in the survey involved taking a number of sample plots systematically throughout infected plantations to determine the severity of the disease. Sample strips were laid out at 5-chain intervals, beginning 2½ chains from the plantation boundary, across each plantation. Sample plots were taken at 5-chain intervals along each strip, beginning 2½ chains from the starting point. Each sample plot consisted of 20 trees or planting spaces. Five trees or planting spaces on each of the two rows in front of, and five trees or spaces on each of the same two rows behind, the plot center were examined. Missing trees or vacant spaces that represented probable seedling locations were tallied as missing on the plot data sheets.

The data recorded on the plantation and plot tally sheets included the species, year and season planted or replanted, plantation and infected acreage, topography, aspect, exposure, and tree condition and symptom classes. The tree condition classes included healthy, dead, dying, missing, and poor vigor. The symptom classes included the yellow-green discoloration, dead laterals or terminals, stem cankers, and other disease and insect damage.

Each tree on the plot was examined individually for any symptom or abnormal condition that might be present. The bark was removed from damaged portions of all the symptomatic trees to determine the presence or absence of the yellow-green discoloration. This provided an estimate of the present amount of fungus infection. Any additional disease and insect problems detected on the sample plots were also recorded.

A map was drawn of each infected plantation, showing the location of the plantation, distribution of the disease within the plantation, and the location of topographic features, such as depressions and ridges that were encountered.

RESULTS

Scleroderris pine canker is widespread over the Ottawa and Hiawatha National Forests in the Upper Peninsula of Michigan and the Nicolet and Chequamegon National Forests in northern Wisconsin. The disease is present on every ranger district on these four forests where red or jack pine has been planted since 1955. The disease has not been detected, however, from limited spot-check examinations on either the Huron-Manistee National Forest in lower Michigan or the Chippewa and Superior National Forests in northern Minnesota. The present known distribution of the disease on National Forest lands in the Lake States is shown in Figure 1.

The most severe damage, in terms of present infection and mortality, has occurred on the Ottawa and Hiawatha National Forests in Upper Michigan. Considerable losses have also occurred on both the Chequamegon and Nicolet National Forests in northern Wisconsin. Some degree of mortality was observed on every ranger district surveyed on all four Forests. The disease situation on each Forest is summarized in Tables 1 and 2.

Ottawa National Forest

Scleroderris pine canker is presently widespread and causing severe losses to both jack and red pine plantations on this Forest. (Figure 2, page 18). The disease was most widespread on the Kenton, Ontonagon, and Watersmeet Ranger Districts. All the red pine plantations sampled on these three Districts were infected. Within the Forest, 21 of the 27 red pine plantations sampled were infected by *S. lagerbergii*. Eight percent of the total number of trees examined within the 21 plantations were infected. The average mortality was 43 percent; 32 percent missing trees and 11 percent dead and dying trees. One-half of the dead and dying red pines were infected by the fungus.

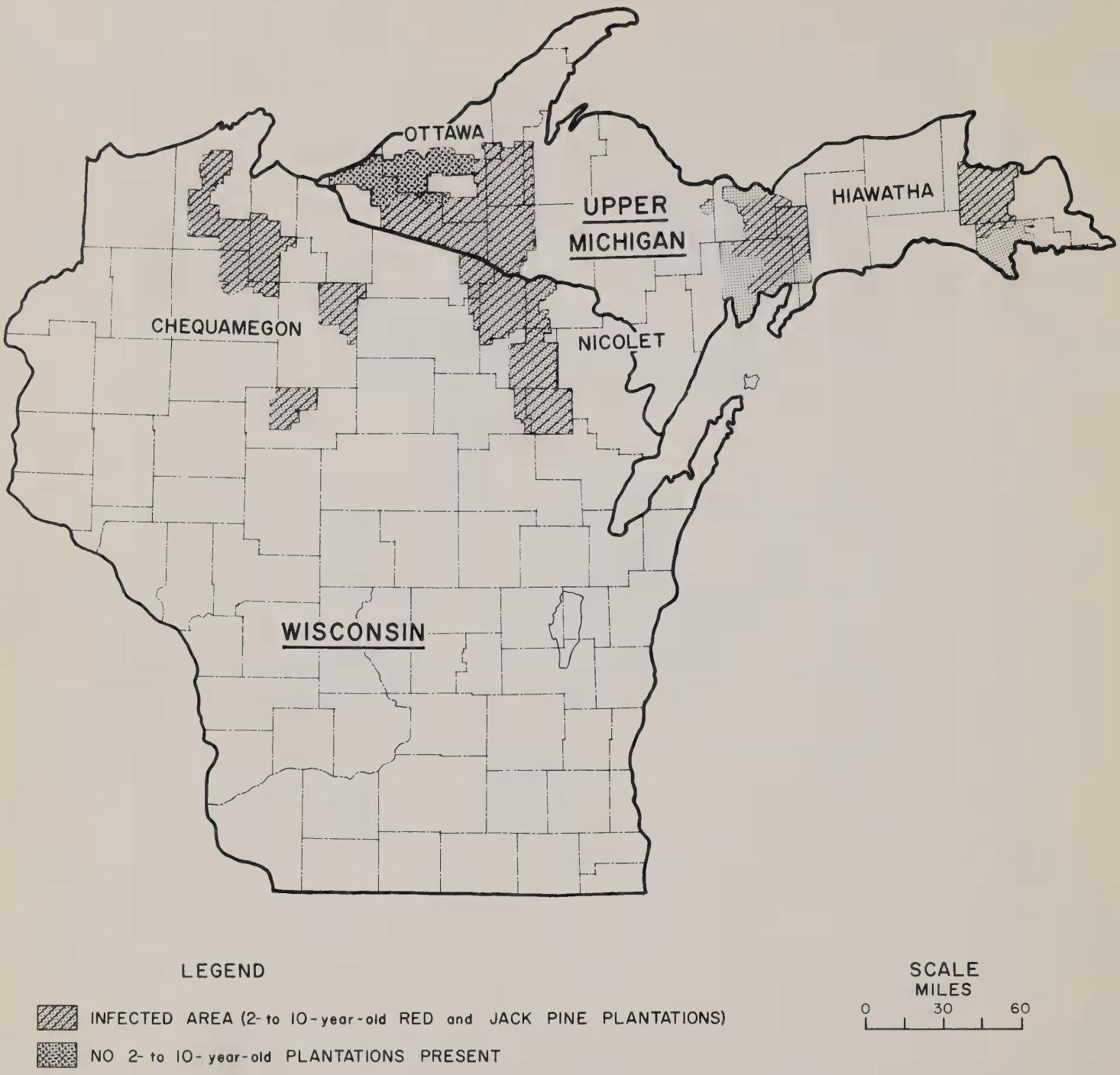

FIGURE 1. THE DISTRIBUTION OF SCLERODERRIS CANKER ON NATIONAL FOREST LANDS IN THE LAKE STATES - 1965.

Table 1. The Incidence of **Scleroderris Pine Canker** in Two- to Ten-Year-old Red Pine Plantations on Four Lake States National Forests

National Forest	Sample Plantations				Plantation Mortality Percent of Trees		Infected Trees 3/
	Examined	Infected		Average	Missing 1/	Dead and Dying 2/	
	Number	Number	Percent	Acreage			Percent
Ottawa	27	21	78	37	32	11	8
Hiawatha	52	34	65	51	31	10	10
Nicolet	51	30	59	24	29	10	3
Chequamegon	46	31	67	38	36	4	3
Total	176	116	66	38	32	8	6

1/ The causal agent could not be determined for the missing trees.

2/ Forty-four percent of these trees were infected with S. lagerbergii.

3/ Includes only the remaining trees with active S. lagerbergii infection in 1965.

Table 2. The Incidence of SCLERODERRIS PINE CANKER in Two- to Ten-year-old Jack Pine Plantations on Three Lake States National Forests

National Forest 1/	Sample Plantations				Plantation Mortality Percent of Trees		Infected Trees 4/
	Examined	Infected		Average	Missing 2/	Dead and Dying 3/	
	Number	Number	Percent	Acreage			Percent
Ottawa	4	3	75	18	15	8	9
Hiawatha	6	6	100	93	40	10	12
Chequamegon	4	3	75	40	24	6	8
Total	14	12	86	57	30	9	10

1/ The only Forests with two- to ten-year-old jack pine plantations.

2/ The causal agent could not be determined for this mortality.

3/ Seventy-seven percent of these trees were infected with S. lagerbergii.

4/ Includes only the remaining trees with active S. lagerbergii infection in 1965.

Three of the four jack pine plantations sampled were found infected. Nine percent of the total number of trees examined within the three plantations were infected. The average mortality was 23 percent; 15 percent missing trees and 8 percent dead and dying trees. One-half of the dead and dying jack pines were infected.

The Watersmeet Ranger District had the heaviest total red pine mortality on the Forest, averaging 86 percent in the five plantations sampled. The Ontonagon Ranger District had the heaviest jack pine losses. The one jack pine plantation, within the two- to 10-year-old age group on this District, had 58 percent mortality. The disease situation within each of the 27 red pine, and 4 jack pine, plantations sampled on the Forest is shown in Table 3, (page 19).

Hiawatha National Forest

The disease is also widespread and causing severe losses to jack as well as red pine plantations on this Forest, (Figure 3, page 20). **Scleroderris pine canker** was most widespread on the Munising, Manistique an ault Ste. Marie Ranger Districts. Over two-thirds (67 percent) of the red pine and all (100 percent) of the jack pine plantations sampled on these Districts were infected.

On the Forest, 34 of the 52 red pine plantations sampled were infected by the fungus. Ten percent of the total number of trees examined within the 34 plantations had active S. lagerbergii infection. Mortality averaged 41 percent; 31 percent missing trees and 10 percent dead and dying trees. Forty-six percent of the dead and dying red pines were infected.

All six of the jack pine plantations sampled were infected. Twelve percent of the total number of trees examined within the six plantations had the fungus present. Mortality averaged 50 percent; 40 percent missing trees and 10 percent dead and dying trees. Eighty-four percent of the dead and dying jack pines were infected.

The Munising Ranger District had the most severe red pine mortality on the Forest. Eight infected plantations sampled had an average of 48 percent mortality. Red pine mortality within infected plantations was also very severe on the Manistique and Sault Ste. Marie Districts, averaging 44 percent and 37 percent, respectively. A large number of infected lateral branches, on otherwise healthy red pines, were also detected on the Manistique District. This accounts for the large amount (22 percent) of S. lagerbergii infection detected on this District. Jack pine mortality was severe on both the Munising and Sault Ste. Marie Ranger Districts in five- to ten-year-old plantations. The disease occurrence within each of the 52 red pine and 6 jack pine plantations sampled on the Forest is summarized in Table 4 (page 21).

Nicolet National Forest

Scleroderris pine canker is widespread and causing severe losses in red pine plantations planted since 1955 on this Forest. (Figure 4, page 22). There are no two- to 10-year-old jack pine plantations on the Forest. The disease was most widespread over the Eagle River and Three Lakes Ranger Districts. Over 85 percent of the plantations sampled on these two Districts were infected. Within the Forest, 30 of the 51 red pine plantations sampled were infected by S. lagerbergii. The fungus was detected on three percent of all the trees examined within the 30 plantations. The average mortality was 39 percent; 29 percent missing trees and 10 percent dead and dying trees. One-third of the dead and dying trees were infected.

The heaviest losses have occurred on the Eagle River Ranger District. Seven infected red pine plantations sampled had an average of 47 percent mortality. The Florence and Three Lakes Districts also had severe mortality within infected plantations. The total mortality on both these Districts averaged 34 percent. Table 5, (page 23) summarizes the incidence of **Scleroderris pine canker** within each of the 51 red pine plantations sampled.

Chequamegon National Forest

The widespread distribution of **Scleroderris pine canker**, mainly in red pine plantations, on this Forest is shown in Figure 5, (page 24). The disease is also widespread in jack pine plantations on the Forest's Washburn Ranger District. This is the only District with two- to ten-year-old jack pine plantations. The disease was most widespread over the Park Falls and Washburn Ranger Districts. One hundred percent of the red pine plantations sampled on the Park Falls District were infected. Eighty-seven percent and 75 percent respectively of the red and jack pine plantations sampled on the Washburn District were infected.

On the Forest, 31 of the 46 red pine plantations sampled were infected by the fungus. Three percent of the total number of trees examined within the 31 plantations had active S. lagerbergii infection. Mortality averaged 40 percent; 36 percent missing trees and four percent dead and dying trees. Fifty-three percent of the dead and dying red pines were infected.

Three of the four jack pine plantations sampled were infected. Eight percent of the total number of trees examined within the three plantations had the fungus present. Mortality averaged 30 percent; 24 percent missing trees and six percent dead and dying trees. Forty-three percent of the dead and dying jack pines were infected.

The most severe mortality within the infected red pine plantations has occurred on the Hayward Ranger District. Four infected red pine plantations had an average of 52 percent mortality. Severe mortality in infected plantations has also occurred on the Glidden and Washburn Districts. Five infected red pine plantations on the Glidden District, and 13 infected plantations on the Washburn District, had mortality averages of 46 percent and 39 percent, respectively. The incidence of the disease within each of the 46 red pine and 4 jack pine plantations sampled is summarized in Table 6, (page 25).

DISCUSSION

The most significant results obtained from the survey were the widespread distribution of **Scleroderris pine canker** and the large amount of mortality that has occurred. The percent of average mortality as well as the percent of infected plantations was surprisingly similar on the four National Forests.

The survey revealed that jack pine as well as red pine was very susceptible to the disease. The sampled jack pine plantations, however, were much older (average, eight years) than the sampled red pine plantations which averaged only four years old. Benzie's outplanting study showed that both species were susceptible to infection by the fungus. However, mortality in the five-year-old jack pine plantings averaged less than one-half the mortality in red pine plantings of the same age. These observations suggest that jack pine may be more resistant to the disease than red pine up to five years old. Older jack pine plantations may become severely infected, however, as evidenced by the five- to ten-year-old plantations sampled during the survey.

The age of the infected plantations (both red and jack pine) should be remembered when interpreting the survey results. Seventy-four percent of all the infected plantations sampled on the four Forests were planted between 1960 and 1963. This two- to five-year-old age group also had an average of 37 percent mortality. Based on field observations, these plantations will remain susceptible to the disease for at least five more years. If the present rate of mortality continues, the majority of these plantations will be wiped out before they are 10 years old.

The present method of taking the plantation survival counts does not reflect the total mortality that has occurred. The survival counts are based on stocking and are made when the plantations are one and five years old. Any plantation with 750 trees per acre is considered fully stocked. Since 800 to 1,000 trees per acre are normally planted, as much as 25 percent mortality can occur without being shown on the plantation survival records. This mortality is very significant when dealing with a fungus such as *S. lagerbergii*.

Both the incidence of the disease and the occurrence of mortality have increased at an accelerated rate in the past five years. This is based on the high percentage of two- to five-year-old infected plantations, with severe mortality detected during the survey. Several 1964 and 1965 red pine plantations were also infected, with severe mortality already occurring in some cases. The accelerated red pine planting program on National Forest lands in the Lake States within the past five years has apparently provided a widespread host for a virulent pathogen.

The widespread distribution of the disease in the young red pine plantations suggests that either the fungus is capable of rapidly infecting susceptible hosts over long distances, or that the planting stock is infected in the nursery. Samples have been taken for laboratory diagnoses from both the Toumey Nursery at Watersmeet, Michigan, and the Chittenden Nursery at Wellston, Michigan. The laboratory results have all been negative to date. The fungus was detected in red pine windbreak trees, however, on the north side of the Toumey Nursery. Samples are being collected (every two weeks) from the nurseries in an effort to determine the presence or absence of the disease in the nursery stock.

Although the fungus was positively identified in all the infected plantations, not all the missing tree mortality can be attributed to the disease. Other factors such as insects (primarily white grubs), animal damage (deer and rabbits), and poor planting practices were observed in a number of the plantations. The strong correlation, however, between the percentage of dead and dying trees and the percentage of remaining trees with S. lagerbergii infection is significant. Forty-four percent and 77 percent respectively, of all the dead and dying red and jack pines examined, were infected by the fungus. This suggests that a large percentage of the total mortality can be attributed to the disease.

There was no significant difference between the percentage of infected plantations planted in the spring and fall. Seventy-three percent of the spring plantings were infected while 60 percent of the fall plantings were also infected. The average percentage of mortality was much higher, however, in the fall plantings. Mortality averaged 48 percent in the fall plantings while it averaged only 26 percent in the spring plantings. This indicates that the planting season has very little bearing upon the plantation becoming infected, but that spring plantings may have almost twice as much chance of survival as fall plantings.

Any type of cover seemed to influence the percentage of infected plantations and the percentage of mortality that occurred. Seventy-nine percent of the plantations planted on open, exposed sites were infected; 51 percent of the plantations growing under cover such as aspen sprouts were infected. The average mortality

on the exposed and covered sites was 42 percent and 20 percent, respectively. Similar results have been obtained in Sweden and Canada (Kohh (7), Martin (8)). Kohh attributes this difference to significantly higher temperatures and fewer nights with frost on covered sites. Frost injuries may serve as major infection courts for S. lagerbergii into young susceptible trees.

The disease was detected most frequently in depressions or "frost pockets". Frost pockets, or localized areas with poor air drainage, have been observed to have significantly lower temperatures and more nights with frosts than the surrounding terrain (5, 10). However, 74 percent of the plantations planted on "flat" sites were also infected. The disease apparently originated in the frost pockets and spread out onto the flat portions of several plantations. Mortality was equally severe on both of the above sites. Frost pockets can easily be misinterpreted in the Lake States as they can have artificial as well as natural origin. Flat, open fields surrounded by large trees can be as much of a frost pocket as natural depressions in some cases.

The most obvious symptoms associated with the disease were dead terminals and lateral branches (flagging), stem cankers, and the yellow-green discoloration beneath the bark of infected trees. As stated previously, the yellow-green discoloration symptom was very reliable in identifying the presence of the fungus in the field. The symptoms were at a peak in July and August but were easily discernible from May until November.

CONCLUSION

The survey results show that **Scleroderris pine canker** is far more sérious on the four National Forests surveyed than was previously realized. At this time, the disease presents a serious threat to existing and future young red and jack pine plantations on these Forests.

If mortality continues at the present rate, the future of red and jack pine plantations (less than ten years old) in these areas is dim. Until control measures are developed, the continued use of these species for reforestation should be drastically reduced or possibly eliminated.

RECOMMENDATIONS

A. Management Practices

The following management practices are recommended in an effort to reduce the incidence of the disease in existing and future pine plantations:

1. Discontinue the replanting of either red or jack pine on previously infected sites until suitable control methods are developed. All potential planting sites should be examined by Forest personnel to determine the presence or absence of the disease.

2. Substantially reduce or discontinue the initial planting of either species on ranger districts where mortality has been severe. Planting plans should be carefully reviewed, in view of the present mortality, to utilize stock now in the nursery and to formulate a basis for future sowings.

3. When planting is done, favor spring plantings over fall plantings as much as possible.

4. Avoid natural depressions or low flat areas (frost pockets) as planting sites.

5. Whenever compatible with current silvicultural practices, conversion plantings should be made in a manner that will provide cover for the young pines.

6. Suggest a revision of current method of making the survival counts. The survival counts would provide more pathological and entomological data if based on the total number of trees planted instead of percentage stocking. Any losses that occur should also be attributed to a causal agent, if possible.

B. Control Test Treatments

The following control test treatments are recommended as cooperative field evaluation studies between the Eastern Region, State and Private Forestry, and the North Central Forest Experiment Station:

1. A spray program, using a manganese fungicide, should be developed for the Toumey Nursery at Watersmeet, Michigan. The spray program should be designed as an evaluation to determine the effectiveness of this treatment in Lake States Forest Nurseries.

2. Control burning should be evaluated in selected severely infected plantations to determine the effectiveness of this treatment in reducing the fungus inoculum source to tolerable levels. Favorable results have been obtained from burning diseased sites in Sweden.

3. Pathological pruning should be evaluated in selected older red pine plantations (six or more years old) to determine the effectiveness of this practice in reducing mortality. The lateral branches normally covered by snow should be pruned. The infected red pine plantations on the Manistique District should be suitable for this evaluation.

4. Additional coniferous species, such as spruce and white pine, should be established on infected sites to determine the susceptibility of these species to the disease.

C. Research Action

The following research action is recommended to facilitate resolution of this disease problem:

1. Continue present cooperation with Forest Insect and Disease Control on Scleroderris surveys.

2. Assist Insect and Disease Control and NFA in conducting control evaluations of the type recommended above under B, with emphasis on development of plans and evaluation of results.

3. An intensive and expanded program of research is recommended in several major areas to effectively resolve the problem. Detailed studies are needed on the life history and basic biology of the fungus to determine: when, under what conditions, and how infection occurs; what are the sources of inoculum, and how does it spread; and what tree species are susceptible. Microclimatic studies are indicated. The low temperature requirements of the fungus and the patchy distribution of severe infection in the field indicate that microenvironmental factors are important. Studies on site relationships to disease attack appear important. A major research effort is needed in this area to provide a sound basis for estimating the hazard levels on specific sites and to provide information on how tree cover can best be manipulated to reduce losses.

4. It is recognized that research is putting as much effort into the Scleroderris problem as is possible with its available resources. This effort, however, is far from adequate, and resources for this work must be substantially increased.

D. Surveys and Evaluations

The following practices are recommended to further evaluate the potential threat of the disease to pine plantations in the Eastern Region:

1. Permanent sample plots should be established in infected plantations throughout the infected area to determine the rate of infection and subsequent mortality by the disease.

2. Similar surveys should be conducted on the remaining National Forests in the Eastern Region where red or jack pine has been planted since 1955. The survey techniques should remain as similar as possible to facilitate the comparison of the survey results.

3. The survey data should be set up for automatic data processing. The ADP should be designed to facilitate the addition of data as it is collected.

4. The National Forest nurseries in the infected area should be inspected at least three times annually (May, August, and October) by the Forest Insect and Disease Control Pathologist.

5. The States of Michigan and Wisconsin should be well informed of the potential disease hazard so they can plan similar surveys for their state and private lands.

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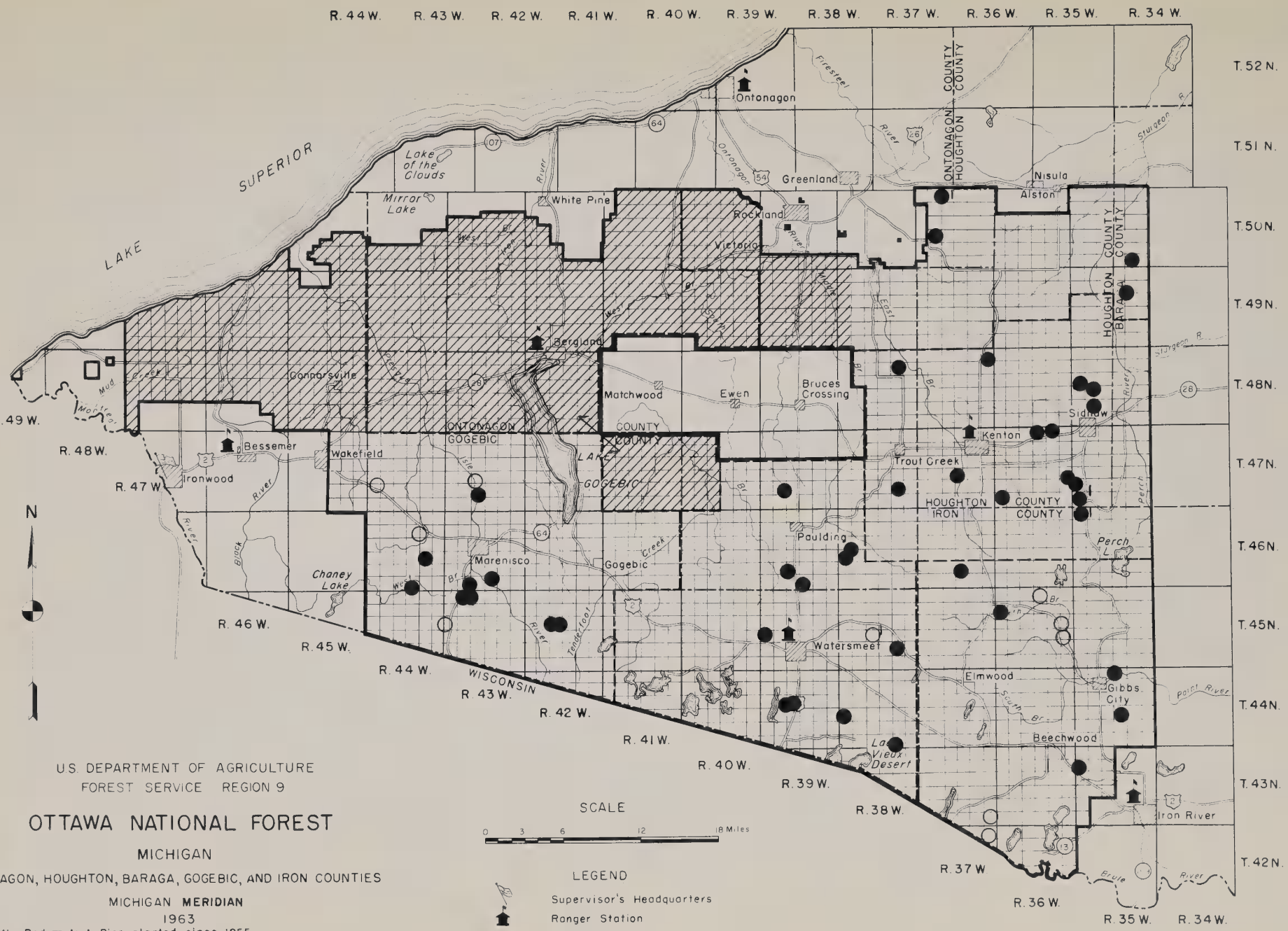
APPENDIX



U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE REGION 9

OTTAWA NATIONAL FOREST

MICHIGAN

ONTONAGON, HOUGHTON, BARAGA, GOGEBIC, AND IRON COUNTIES

MICHIGAN MERIDIAN

1963

- No Red or Jack Pine planted since 1955
- Infected Plantation — Red Pine
- Negative Plantation — Red Pine
- Infected Plantation — Jack Pine
- Negative Plantation — Jack Pine

Figure 2. The Distribution of Scleroderris Pine Canker in Two to Ten-Year-Old Red and Jack Pine Plantations on the Ottawa National Forest

TABLE 3

The Incidence of Scleroderris Pine Canker in Two to Ten-Year-Old Red and Jack Pine Plantations - Ottawa National Forest

RANGER DISTRICT	PLANTATION NUMBER	BRUNCHORSTIA DIEBACK		NUMBER PLOTS	PLOTS INFECTED		PLOT MORTALITY - PERCENT 2/		INFECTED TREES
		PRESENT	ABSENT	SAMPLED 1/	NUMBER	PERCENT	MISSING TREES	DEAD AND DYING TREES	PERCENT 3/
ONTONAGON	87 E (J.P.)	X		5	5	100	41	17	17
	75 A	X		14	13	93	12	20	14
	P 5007	X		8	8	100	23	8	11
	TOTAL (RED PINE)	2	0	22	21	95	17	16	12
	TOTAL (JACK PINE)	1	0	5	5	100	41	17	17
KENTON	P 27 D	X		9	6	67	4	15	5
	P 4012 D (J.P.)	X		5	3	60	1	2	5
	P 4022 B	X		6	4	67	9	8	7
	P 4018	X		0	NO PLOTS MEASURED - ONLY THREE INFECTED TREES				
	P 4013 A (J.P.)	X		5	3	60	2	4	5
	P 4020 A	X		0	NO PLOTS MEASURED - 75 PERCENT OF TREES MISSING				
	P 4022 B	X		17	4	24	4	3	2
	TOTAL (RED PINE)	5	0	32	14	44	18	7	4
	TOTAL (JACK PINE)	2	0	10	6	60	2	3	5
IRON RIVER	P 3017 B	X		3	3	100	18	7	5
	P 3027 C	X		9	9	100	18	28	24
	P 3022		X	0	-	-	-	-	-
	P 3026 C		X	0	-	-	-	-	-
	P 3025 D	X		8	3	38	12	3	2
	P 3026 A		X	0	-	-	-	-	-
	TOTAL (RED PINE)	3	3	20	15	75	16	15	13
WATERSMEET	P 6019 D	X		2	2	100	30	8	5
	P 6019 E	X		2	2	100	33	33	5
	6021 A - C	X		1	1	100	30	5	5
	6021 A & E	X		0	NO PLOTS MEASURED - 75 PERCENT OF TREES MISSING				
	6019 E	X		0	NO PLOTS MEASURED - 75 PERCENT OF TREES MISSING				
	T45-R38-S16&21(J.P.)		X	0	-	-	-	-	-
	TOTAL (RED PINE)	5	0	5	5	100	69	17	5
	TOTAL (JACK PINE)	0	1	0	-	-	-	-	-
BESSEMER	P 2015 C	X		5	3	60	27	6	4
	P 2019 I	X		12	12	100	23	9	10
	P 2007	X		7	2	29	19	3	4
	P 2011	X		8	5	63	31	8	14
	P 2015 G	X		0	NO PLOTS MEASURED - ONLY ONE INFECTED TREE				
	P 2019 M	X		0	NO PLOTS MEASURED - ONLY FIVE - SIX INFECTED TREES				
	P 2017 G		X	0	-	-	-	-	-
	P 2017 F		X	0	-	-	-	-	-
	P 2017 D		X	0	-	-	-	-	-
	TOTAL (RED PINE)	6	3	32	22	69	25	7	9
FOREST	TOTAL (RED PINE)	21	6	111	77	70	32	11	8
	TOTAL (JACK PINE)	3	1	15	11	73	15	8	9

1/ EACH PLOT CONSISTED OF 20 TREES AND/OR PLANTING SPACES.

2/ THE CAUSAL AGENT COULD NOT BE DETERMINED FOR THE MISSING TREES. THE FUNGUS WAS POSITIVELY IDENTIFIED, HOWEVER, IN ALL THE INFECTED PLANTATIONS.

3/ INCLUDES ONLY THE REMAINING TREES (MOSTLY DEAD AND DYING) WITH ACTIVE S. LACERBERGII INFECTION IN 1965.

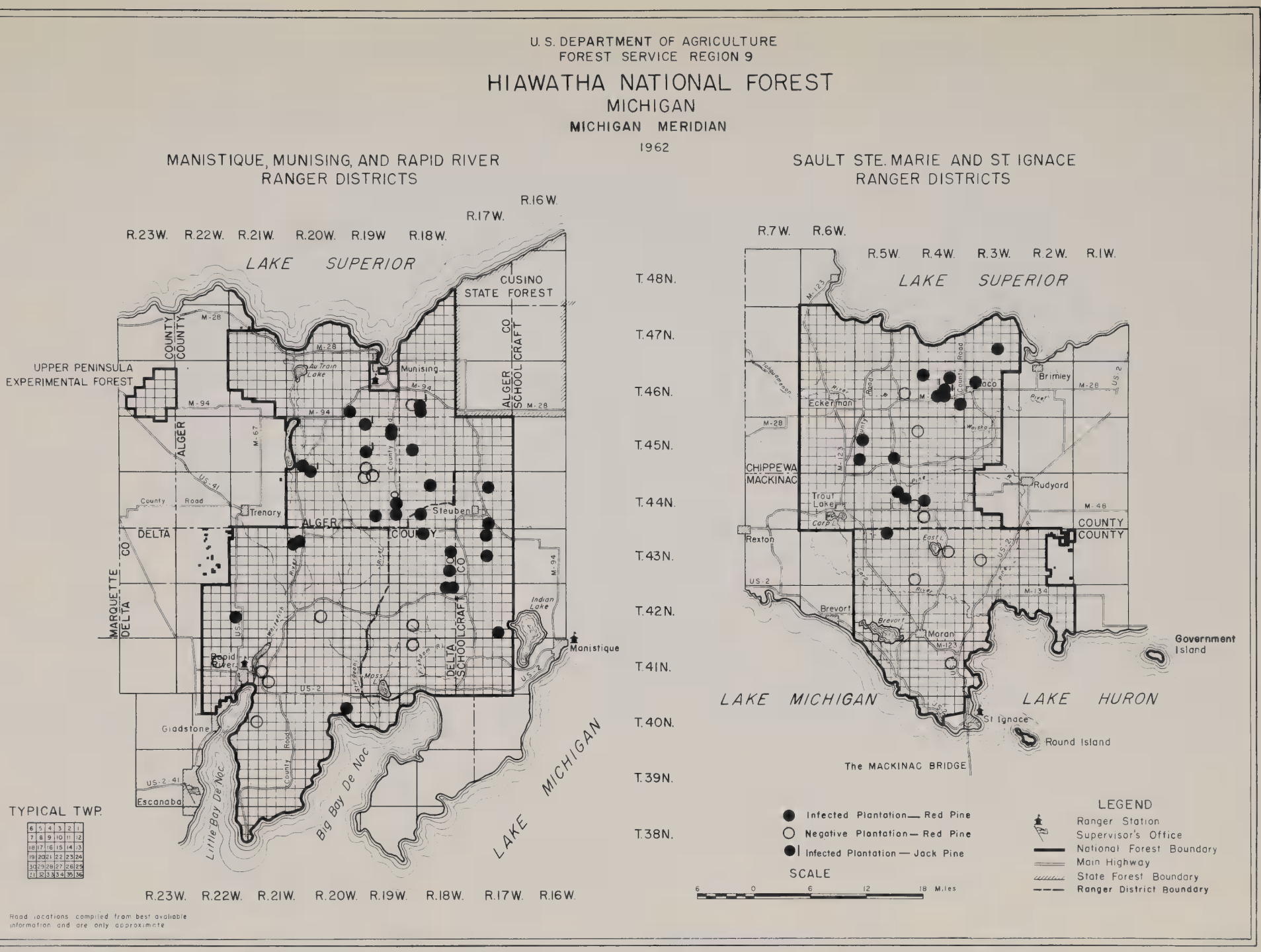


Figure 3. The Distribution of Scleroderris Pine Canker in Two to Ten-Year-Old Red and Jack Pine Plantations on the Hiawatha National Forest

TABLE 4

The Incidence of Scleroderris Pine Canker in Two to Ten-Year-Old Red and Jack Pine Plantations - Hiawatha National Forest

RANGER DISTRICT	PLANTATION NUMBER	BRUNCHORSTIA DIEBACK		NUMBER PLOTS	PLOTS INFECTED		PLOT MORTALITY - PERCENT [2]		INFECTED TREES
		PRESENT	ABSENT	SAMPLED [1]	NUMBER	PERCENT	MISSING TREES	DEAD AND DYING TREES	PERCENT [3]
MUNISING	111 A-R (J.P.)	X		11	7	64	43	5	5
	P 61 A&B-R (J.P.)	X		16	16	100	63	25	27
	125 - C (J.P.)	X		4	4	100	49	6	9
	P 130 A-D (J.P.)	X		28	20	71	24	5	8
	122 A-R	X		12	10	83	13	10	9
	139 - E		X	0	-	-	-	-	-
	133 - C		X	0	-	-	-	-	-
	137 - F		X	0	-	-	-	-	-
	139 - B		X	0	-	-	-	-	-
	124 - A	X		7	6	86	57	4	5
	129 - B	X		3	2	67	20	3	5
	126 - D	X		15	7	47	44	4	2
	118 - B-R	X		19	15	79	42	19	12
	133 A-R	X		12	3	25	6	10	1
	P 131 A - (2)	X		10	9	90	58	5	7
	P 131 - B	X		25	8	32	48	2	2
	TOTAL (RED PINE)	8	4	103	60	58	38	8	5
	TOTAL (JACK PINE)	4	0	59	47	80	40	10	12
RAPID RIVER	128 - D	X		3	1	33	17	3	3
	129 - D	X		4	3	75	20	15	5
	131 - F	X		4	3	75	33	14	8
	133 - D		X	0	-	-	-	-	-
	128 - B - (4)		X	0	-	-	-	-	-
	125 - C		X	0	-	-	-	-	-
	126 - J		X	0	-	-	-	-	-
	TOTAL (RED PINE)	3	4	11	7	64	24	11	5
MANISTIQUE	139 - C		X	0	-	-	-	-	-
	138 - I		X	0	-	-	-	-	-
	137 - D	X		5	2	40	71	14	4
	129 - B	X		6	5	83	46	6	21
	136 - G	X		10	9	90	22	30	17
	126 - F	X		6	6	100	45	13	48
	125 - G	X		11	11	100	15	16	82
	128 - C	X		5	4	80	24	0	9
	136 - C	X		8	5	63	44	13	6
	134 - C	X		11	6	55	7	25	6
	139 - I	X		0	NO PLOTS MEASURED - ONLY SIX - EIGHT INFECTED TREES				
	138 - N	X		14	1	7	34	5	2
	TOTAL (RED PINE)	10	2	76	48	63	30	14	22
SAULT STE. MARIE	150 - A (J.P.)	X		0	NO PLOTS MEASURED - PLANTATION WIPED OUT				
	150 - B (J.P.)	X		0	NO PLOTS MEASURED - PLANTATION WIPED OUT				
	T 45 R 4 S 5		X	0	-	-	-	-	-
	162 - H		X	0	-	-	-	-	-
	158 - A		X	0	-	-	-	-	-
	161 - J		X	0	-	-	-	-	-
	159 - E	X		16	3	19	13	6	1
	143	X		20	12	60	54	5	5
	147 - E	X		0	NO PLOTS MEASURED - 75 PERCENT OF TREES MISSING				
	161 - K	X		8	7	88	10	22	15
	157 - D	X		8	2	25	49	3	2
	159 - I	X		13	2	15	11	1	1
	161 - B	X		8	8	100	14	34	27
	T 46 R 3 S 17	X		16	2	13	28	11	1
	159 - G	X		16	8	50	29	4	4
	156 - A	X		8	4	50	46	3	3
	149 - A	X		6	5	83	25	8	13
	148 - A	X		10	5	50	34	7	4
	TOTAL (RED PINE)	12	4	129	58	45	33	8	5
	TOTAL (JACK PINE)	2	0	0	NO PLOTS MEASURED - BOTH PLANTATIONS WIPED OUT				
ST. IGNACE	113	X		17	1	6	38	2	1
	P V		X	0	-	-	-	-	-
	111 (south)		X	0	-	-	-	-	-
	111 (north)		X	0	-	-	-	-	-
	P I		X	0	-		-	-	-
	TOTAL (RED PINE)	1	4	17	1	6	38	2	1
FOREST	TOTAL (RED PINE)	34	18	336	174	52	31	10	10
	TOTAL (JACK PINE)	6	0	59	47	80	40	10	12

1/ EACH PLOT CONSISTED OF 20 TREES AND/OR PLANTING SPACES.

2/ THE CAUSAL AGENT COULD NOT BE DETERMINED FOR THE MISSING TREES. THE FUNGUS WAS POSITIVELY IDENTIFIED, HOWEVER, IN ALL THE INFECTED PLANTATIONS.

3/ INCLUDES ONLY THE REMAINING TREES (MOSTLY DEAD AND DYING) WITH ACTIVE S. LAGERBERGII INFECTION IN 1965.

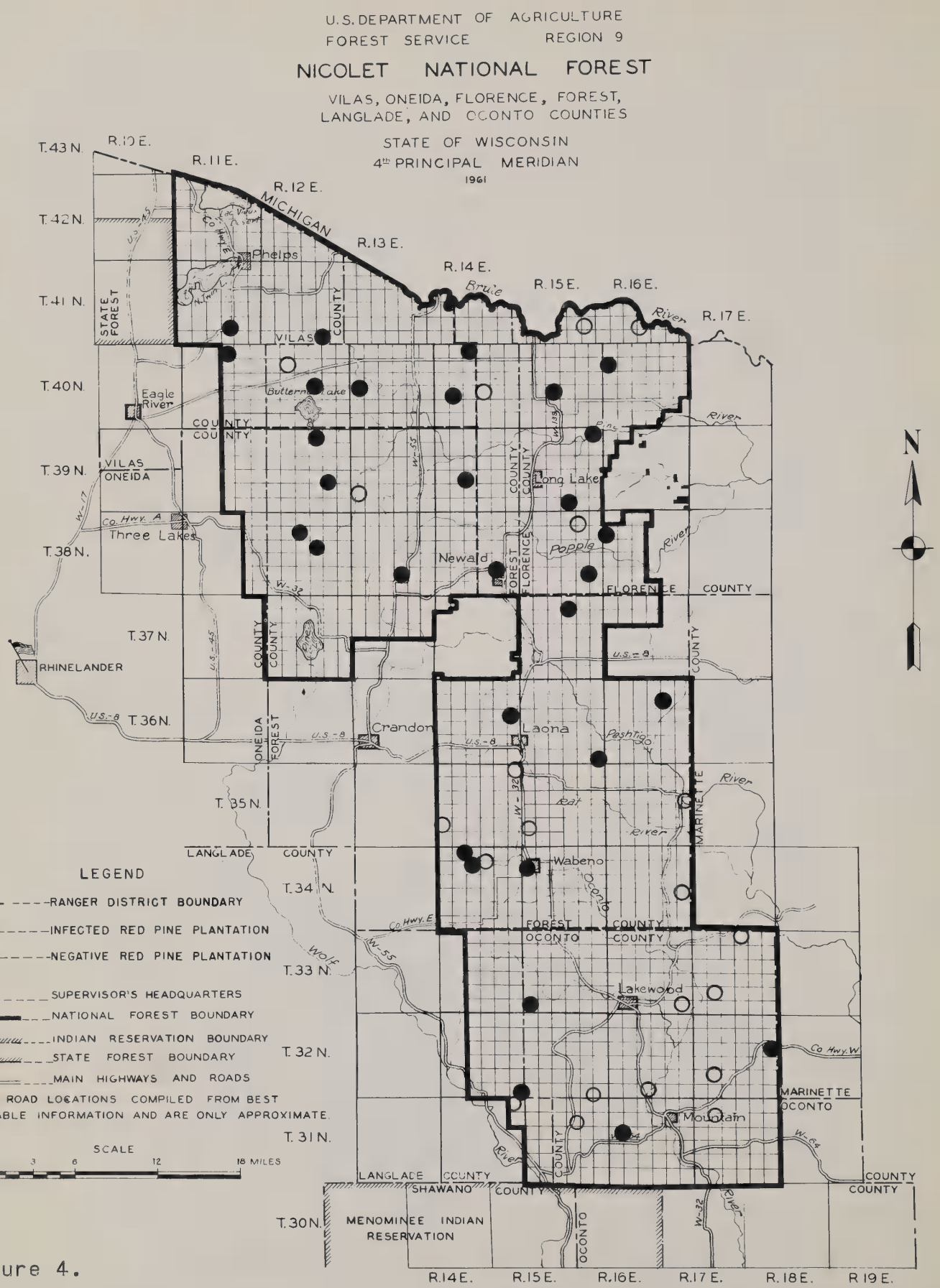


Figure 4.

The Distribution of Scleroderris Pine Canker in Two to Ten-Year-Old Red Pine Plantations on the Nicolet National Forest

TABLE 5

The Incidence of Scleroderris Pine Canker in Two to Ten-Year-Old Red Pine Plantations - Nicolet National Forest

RANGER DISTRICT	PLANTATION NUMBER	BRUNCHORSTIA DIEBACK		NUMBER PLOTS	PLOTS INFECTED		PLOT MORTALITY - PERCENT 2/		INFECTED TREES
		PRESENT	ABSENT	SAMPLED 1/	NUMBER	PERCENT	MISSING TREES	DEAD AND DYING TREES	PERCENT 3/
EAGLE RIVER	49 E	X		5	4	80	45	3	4
	50 C	X		8	7	88	33	23	11
	52 - ?	X		6	3	50	18	10	5
	52 C	X		4	4	100	20	13	13
	49 D		X	0	-	-	-	-	-
	49 A	X		15	7	47	22	8	3
	52 A	X		13	1	8	45	18	1
	49	X		15	11	73	35	34	7
	TOTAL	7	1	66	37	56	32	15	5
FLORENCE	P 6 J		X	0	-	-	-	-	-
	P 2 D		X	0	-	-	-	-	-
	P 2 E		X	0	-	-	-	-	-
	P 2 C	X		4	2	50	13	8	6
	P 1 A	X		7	3	43	11	5	5
	P 8 C	X		9	9	100	38	12	11
	P 7 L	X		13	4	31	22	7	2
	P 6 I	X		6	4	67	23	5	4
	P 2 B		X	0	-	-	-	-	-
	P 6 L	X		8	7	88	29	12	6
	P 7 B	X		6	4	67	38	12	3
	TOTAL	7	4	53	33	62	26	8	5
THREE LAKES	T 38 R 12 S 15	X		16	1	6	45	2	1
	P 49 A	X		12	5	42	24	8	3
	P-2	X		9	3	33	30	4	2
	P 46 A&B	X		13	3	23	15	4	3
	P-6		X	0	-	-	-	-	-
	T 39 R 12 S 23	X		0	NO PLOTS MEASURED - PLANTATION WIPED OUT				
	T 38 R 13 S 27	X		9	2	22	28	6	1
	TOTAL	6	1	59	14	24	29	5	2
LAONA	P 6 G	X		0					
	P 6 D		X	0					
	P 15 (16)		X	0					
	P 6 F		X	0					
	P 8 A		X	0					
	P 4 A	X		0	NO PLOTS MEASURED IN ANY PLANTATIONS - THE HEAVY SNOW				
	P 11 A		X	0	COVER MADE INDIVIDUAL TREE EXAMINATIONS IMPOSSIBLE				
	P 4 E	X		0					
	P 6 E		X	0					
	P 6 C	X		0					
	P 6 B	X		0					
	7 D	X		0					
	TOTAL	6	6	0	-	-	-	-	-
LAKEWOOD	P 5 B		X	0	-	-	-	-	-
	P 8 G		X	0	-	-	-	-	-
	P 2		X	0	-	-	-	-	-
	P 8 F		X	0	-	-	-	-	-
	P 2 A		X	0	-	-	-	-	-
	P 4 A		X	0	-	-	-	-	-
	P 2		X	0	-	-	-	-	-
	P 24		X	0	-	-	-	-	-
	P 8 A E		X	0	-	-	-	-	-
	P 26 B	X		9	2	22	27	18	1
	P 10 B	X		7	1	14	30	19	1
	P 9 B	X		10	3	30	16	6	2
	P 9 D	X		15	3	20	25	2	1
	TOTAL	4	9	41	9	22	24	9	1
FOREST	TOTAL	30	21	219	93	42	29	10	3

1/ EACH PLOT CONSISTED OF 20 TREES AND/OR PLANTING SPACES.

2/ THE CAUSAL AGENT COULD NOT BE DETERMINED FOR THE MISSING TREES. THE FUNGUS WAS POSITIVELY IDENTIFIED, HOWEVER, IN ALL THE INFECTED PLANTATIONS.

3/ INCLUDES ONLY THE REMAINING TREES (MOSTLY DEAD AND DYING) WITH ACTIVE S. LAGERBERGII INFECTION IN 1965.

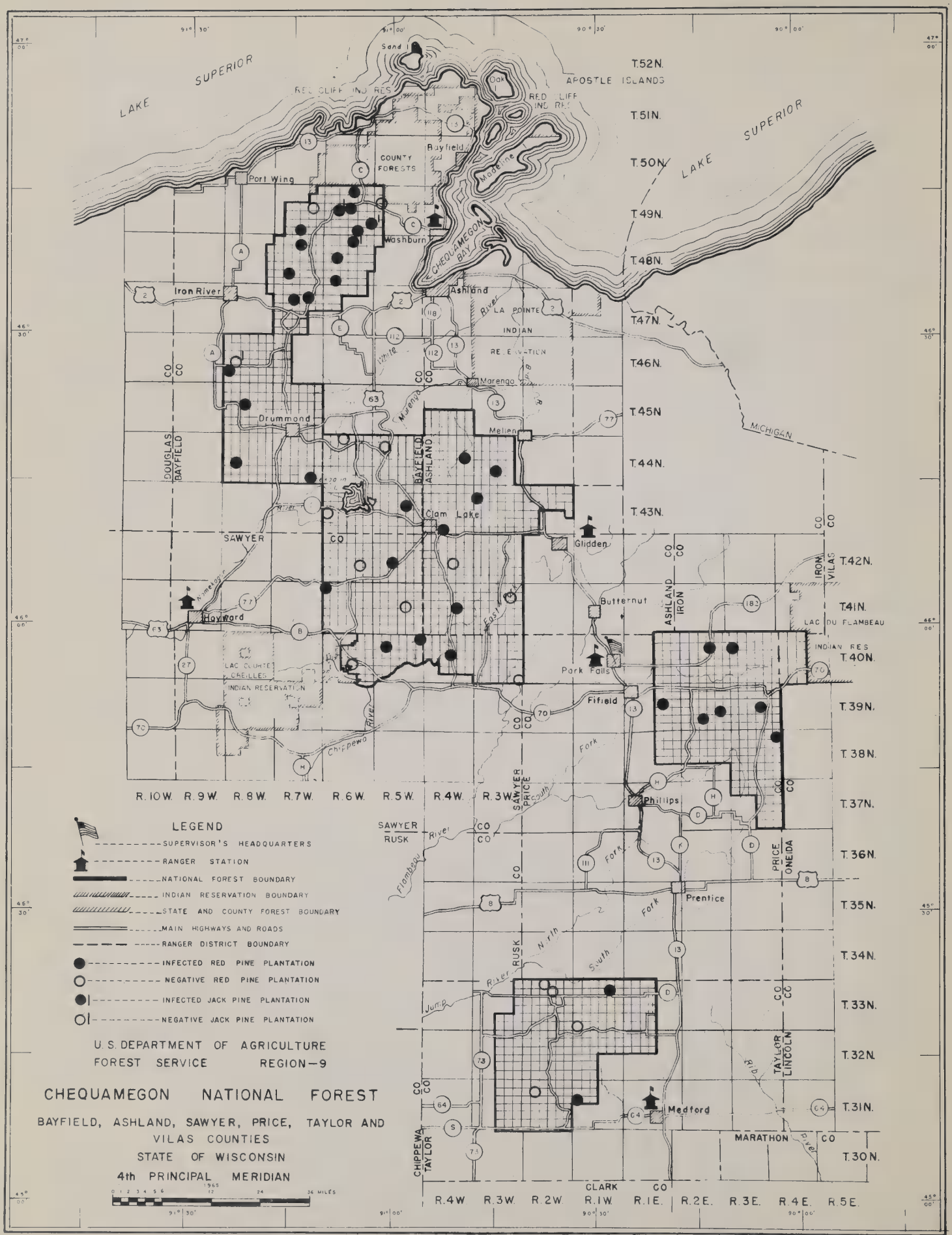


Figure 5. The Distribution of Scleroderris Pine Canker in Two to Ten-Year-Old Red and Jack Pine Plantations on the Chequamegon National Forest

TABLE 6

The Incidence of Scleroderris Pine Canker in Two to Ten-Year-Old Red and Jack Pine Plantations - Chequamegon National Forest

RANGER DISTRICT	PLANTATION NUMBER	BRUNCHORSTIA DIEBACK		NUMBER PLOTS SAMPLED 1/	PLOTS INFECTED		PLOT MORTALITY - PERCENT 2/		INFECTED TREES PERCENT 3/
		PRESENT	ABSENT		NUMBER	PERCENT	MISSING TREES	DEAD AND DYING TREES	
WASHBURN	103 (J.P.)		X	0	-	-	-	-	-
	106 F (J.P.)	X		12	7	58	18	7	10
	106 B (J.P.)	X		3	1	33	47	7	2
	106 C (J.P.)	X		8	1	13	45	1	1
	101		X	0	-	-	-	-	-
	P 95		X	0	-	-	-	-	-
	T 44 R 7 S 34	X		10	3	30	37	1	2
	112 B	X		10	2	20	40	1	1
	117 B	X		17	8	47	25	6	5
	119	X		16	8	50	32	3	4
	111 - A	X		16	2	13	36	2	1
	99	X		9	2	22	4	1	3
	113 - A	X		7	5	71	31	9	4
	T 48 R 7 S3, 9, 10	X		16	3	19	40	4	1
	111 - E	X		7	2	29	50	2	2
	110 - C	X		14	11	79	31	9	9
	T 40 R 6 S 17-20	X		13	11	85	53	12	10
	108 - D	X		9	4	44	26	4	4
	T 49 R 7 S 33-34	X		13	6	46	50	3	3
	TOTAL (RED PINE)	13	2	157	67	43	35	4	4
	TOTAL (JACK PINE)	3	1	23	9	39	24	6	8
PARK FALLS	P 64 B	X		5	1	20	33	1	1
	P 71 F	X		13	1	8	13	4	1
	P 68 B	X		14	1	7	4	2	1
	P 69 C	X		16	4	25	30	7	3
	P 69 A	X		16	8	50	22	3	3
	P 69 B	X		7	4	57	54	6	5
	T 39 R 1 S 22	X		17	1	6	16	2	1
	TOTAL (RED PINE)	7	0	88	20	23	21	4	2
GLIDDEN	P 39 H & I		X	0	-	-	-	-	-
	P 86 B		X	0	-	-	-	-	-
	P 5 R		X	0	-	-	-	-	-
	P 85 C	X		5	3	60	52	2	4
	P 85 B	X		16	2	13	47	1	1
	T 43 R 3 S 7	X		11	1	9	54	1	1
	P 87	X		6	1	17	71	3	1
	T 43 R 4 S 33	X		15	3	20	21	3	1
	TOTAL (RED PINE)	5	3	53	10	19	44	2	1
HAYWARD	P 62 L		X	0	-	-	-	-	-
	P 58		X	0	-	-	-	-	-
	P 59 A		X	0	-	-	-	-	-
	P 59 C		X	0	-	-	-	-	-
	P 62 M		X	0	-	-	-	-	-
	P 56 B		X	0	-	-	-	-	-
	P 62 V	X		9	1	11	68	1	1
	P 62 X, Y, Z	X		11	1	9	61	1	1
	P 61	X		15	5	33	52	4	2
	P 63 T	X		6	4	67	29	12	5
	TOTAL (RED PINE)	4	6	41	11	26	49	3	1
MEDFORD	P 43	X		0					
	P 44 B	X		0					
	P 40 B		X	0					
	P 36 B		X	0					
	P 42 B		X	0					
	P 38		X	0					
	TOTAL (RED PINE)	2	4	0	NO PLOTS MEASURED - VERY FEW INFECTED TREES				
FOREST	TOTAL (RED PINE)	31	15	339	108	32	36	4	3
	TOTAL (JACK PINE)	3	1	23	9	39	24	6	8

1/ EACH PLOT CONSISTED OF 20 TREES AND/OR PLANTING SPACES.

2/ THE CAUSAL AGENT COULD NOT BE DETERMINED FOR THE MISSING TREES. THE FUNGUS WAS POSITIVELY IDENTIFIED, HOWEVER, IN ALL THE INFECTED PLANTATIONS.

3/ INCLUDES ONLY THE REMAINING TREES (MOSTLY DEAD AND DYING) WITH ACTIVE S. LAGERBERGII INFECTION IN 1965.

AN EXAMPLE OF DAMAGE CAUSED BY SCLERODERRIS LAGERBERGII IN THE UPPER PENINSULA OF MICHIGAN. BOTH RED AND JACK PINE PLANTINGS HAVE FAILED IN THIS AREA.